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UNITED STATES DEPARTMENT OF AGRICULTURE

BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE

FOREST INSECT INVESTIGATIONS

PRELIMINARY REVIEW OF STUDIES DEALING WITH MATSUCOCCUS SP. ATTACKING PONDEROSA PINE

by
J. M. Miller and H. L. McKenzie
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J. M. MILLER
Senior Entomologist

and

Howard L. McKenzie
Assistant Entomologist

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PRELIMINARY REVIEW OF STUDIES DEALING WITH MATSUCOCCUS SP. ATTACKING PONDEROSA PINE

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I. SUMMARY OF PROJECT TO DATE.

Early in 1936 the Office of Forest Pathology called attention to the occurrence of scale insects on dead ponderosa pine twigs from the Prescott National Forest. The insects were determined by the Bureau of Entomology and Plant Quarantine as a scale belonging to the genus Matsucoccus. Since then the more important entomological developments of the study concerned with the injury termed "flagging" of ponderosa pine twigs have been about as follows:

In April and May, 1936, a field study was made by Craighead, Morrison and West in the vicinity of Prescott which definitely established the occurrence of the scale in abundance on the areas most seriously affected by the twig blight. Further observational surveys also revealed that the same scale was present on other areas, notably on the Coconino, where flagging injury was prevalent.

Observations were started on the seasonal history and habits of the scale.

An experiment was set up to determine whether flagging could be induced by artificially establishing heavy scale populations on selected twigs. A series of 3 trees were infested in a known area of blight at the Lynx Creek CCC camp; another series of 7 trees were similarly treated by West in a scale-free, flag-free area near Cold Spring.

No further work was conducted during the season of 1936 except for an examination of the experimental trees by Dr. West in December.

Beginning April 1st, 1937, an EOW project was set up under the Forest Insect Laboratory at Berkeley and H. L. McKenzie who was assigned to the project, located at Prescott. A Field Laboratory was made available at the Wolf Creek Transient Camp from which the following work was carried on:

1. A study of the seasonal history and habits of the scale, particular attention being given to the feeding habits and migrations of the larval stages. (Covered in section II of this report.)
2. A histological study of the effects of scale feeding upon the plant tissues.

3. A follow up of the results of the artificial infestation experiments initiated in 1936. (Covered in section III.)
4. Further experiments with artificially infested trees to test the theory that the scale causes flagging. A series of 15 ponderosa pines were selected in a scale-free, flag-free area at the Wolf Creek Laboratory and heavy scale populations established.
5. A field survey during the period from November 14 to 24. to determine the occurrence of Matsucoccus on recently reported blight areas in Arizona and New Mexico. (Covered in section III.)

During the progress of this work, as close contact as possible was maintained with the Forest Pathology laboratory at Prescott. Material from the flags that developed on the artificially infested trees was turned over for study and cultures. The distribution survey made in November was largely a cooperative undertaking with the Albuquerque office under Dr. Gill.

II. SEASONAL HISTORY.

Adult Female Scale. During April 1937 many hundreds of brown adult females of the Matsucoccus sp. scale were observed emerging from the overwintering intermediate of preadult stage. In general appearance this adult female possesses a rather robust body with the posterior end somewhat broader. No functional mouthparts are to be found on the adult female, so that feeding apparently does not take place. This is further substantiated by the fact that frequently the adult females will settle prior to egg laying, on some tip moth killed twig where a crack or cavity has afforded them protection. However, population counts of the mature females with egg sacs and eggs made during the spring of 1937 indicated that they apparently prefer to settle on the 1935-36 and 1936-37 nodes and rarely on the 1933-34 node. As many as 237 mature females have been observed on a 1935-36 node and in one case 161 on a 1936-37 node. There is a tendency for these females to pile upon one another around the nodes. After settling wax is secreted and just prior to egg laying the abdomen of the adult female is retracted or withdrawn into the thoracic portion of the insect thus forming a kind of internal marsupium. It appears as though the whole body has been modified for the reproductive function. Eggs are to be found in the marsupium as well as in the waxy secretions.

Eggs. The small bean-shaped eggs are at first lemon yellow but as they incubate, become a deep orange yellow color. The incubation period of the eggs of the Matsucoccus sp. scale appears to be between 12-23 days depending upon climatic conditions.

First Stage Larvae. The first stage larvae settle under the thin layers of bark on the stem and many are to be found under the bract

enclosing the needle base. The first molt occurs within 38-44 days, depending upon climatic conditions, after the young first settle. Prior to molting there appears to be a quantity of wax secreted from the posterior portion of the body of the insect. This wax appears to be rather short filaments as contrasted withthe long filaments secreted by the adult females.

Second stage larvae. The second stage larvae possess appendages and appears to resemble the first stage except that they are somewhat larger, and that after six or eight days they start to swell in the anterior portion of the body - thus appearing somewhat pyriform in outline. The second molt represents a metamorphic change in which the second stage derm finally ruptures in the anterior part, and for some time the third stage larvae or preadult stage are almost completely enclosed within this derm. As the preadult grows, this derm continues to split until finally the appearance is that of a derm-cup that encloses only the lower portion of the preadult stage. This derm-cup eventually sloughs off by the time the insect has attained the full mature intermediate or preadult stage size. The second molt occurs in approximately 50 days after the first molt.

Intermediate or preadult stage larvae. The third or preadult stage larvae are apodous. Furthermore, it is to be readily observed that there has been a marked change in the spiracles as compared to these structures in either the first or second stage larvae. The pre-adult females are stout, elliptical, nearly circular, and somewhat elongate ovoid with the derm more or less distinctly chitinized. Because of the nature of the new growth on ponderosa pine, no preadults are to be found on the current years growth, with the possible exception of a very few near the first node. The second years growth appears to possess the largest number of insects, while they are less frequent on the third years growth, and rarely on the fourth years growth. As many as 40 preadult larvae have been counted on the second years growth, 37 on the third years growth and 14 on the fourth years growth. They apparently prefer to settle under the bract enclosing the needle base although occasionally some are to be found in cracks and crevices of the bark layers. The developing preadult larvae have not as yet attained (Dec.1937) their full size although by spring this should have taken place.

Male scale. Although hundreds of scale of the various stages have been stained and mounted, no male scales have as yet been observed. However, a differentiation may take place sometime next spring at which time males may be distinguished.

Briefly then, there is a motile adult female that secretes wax and lays eggs, two appendage stage larvae, and an intermediate or apodous preadult stage. A years time is apparently required for this particular species of Matsucoccus to complete its life history.

Necrotic areas. During the second stage of development of the Matsucoccus scale it was observed that in most cases wherever there was

an aggregation of feeding scale that immediately beneath these insects there was a decided necrotic area formed. Furthermore these areas did appear to extend, until finally it was deemed advisable to preserve a considerable amount of material for sectioning. This was done and from the limited number of prepared slides examined there does appear to be a breaking down of cells of the phloem area beneath the insects.

III. ARTIFICIAL INFESTATION EXPERIMENTS.

During the spring of 1936, Dr. A. E. West artificially infested ten (10) ponderosa pine trees with Matsucoccus sp. scale. Three (3) of these experimental trees (A,B and C) were located in the Lynx Creek Area I, while the remaining seven (7) trees(D to J) were located in the Cold Springs Area II. The Lynx Creek Area I was a heavily flagged area while the Cold Springs Area II was located in a scale-free, flag-free area.

In the spring of 1937 some observations were made on these trees with regard to tree health and extent of Matsucoccus population density. There was some winter kill to the needles of experimental tree I in Area II prior to flagging. The extent of infestation of the Matsucoccus scale on the experimental trees in the Lynx Creek Area I, did not apparently differ materially from check trees situated nearby, but did differ from the population of scale found on the experimental trees in the Cold Springs Area II. The Lynx Creek experimental trees appeared to have a greater population density of the preadult scale than did those located at Cold Springs. Population counts of the preadults on check trees in the Lynx Creek area appeared to be as great or greater than on the experimental trees in either the Lynx Creek or Cold Springs areas. Furthermore, preadult scale counts made on the experimental trees in both areas indicated that there was a noticably higher natural mortality of scale in the Cold Springs area than in the Lynx Creek area. On May 24, 1937 the artificially infested trees in the Lynx Creek and Cold Springs areas began to flag. An account of this flagging of the twigs is given in Table I.

It will be observed in the table that Tree B was the only experimental tree that flagged in the Lynx Creek Area I. Trees A and C have not flagged as yet. Individual tree immunity might be the possible explanation for this as there are trees in flagged areas that apparently never flag. Or there might be some correlation of the lower natural mortality of the scale on these trees as compared to those in the Cold Springs Area II, all of which flagged to some extent (see Table I). Both experimental trees A and C in the Lynx Creek Area were fast growing, vigorous specimens.

At the time of the first examination of the flagged twigs on the experimental trees in both areas it was thought that there would be no more flagging of the twigs and so further observations were discontinued until on October 13, 1937. At that time it became quite evident that flagging had continued to take place throughout the season as there were actually

more dead branches on the experimental trees than had previously been recorded. So that flagging of the twigs does apparently continue throughout the season.

In the Cold Springs area every artificially infested tree flagged. Only twigs that had been artificially infested with the Matsucoccus scale flagged, and the remaining uninfested branches on the experimental trees remained in perfect health.

Selection of the Cold Springs area was suggested to Dr. West by the Forest Pathology Laboratory at Prescott because it had been found to be free from flagging in their blight surveys. During the course of the 1937 season an intensive examination was made by McKenzie of many trees in the vicinity of the experimental trees, but no evidence of either scale or flagging was discovered. Apparently the development of flags in this area is either directly or indirectly the result of introduction of the scale Matsucoccus.

IV. DISTRIBUTION OF SCALE AND CORRELATION WITH FLAGGING INJURY.

Occurrence of the scale in all ponderosa areas showing typical flags was noted in the vicinity of Prescott in 1936 and again during the course of the experimental work in 1937. In contrast, great difficulty was encountered in finding the scale in areas which did not show flags. No effort was made, however, to carry out extensive surveys during the 1937 season, as the work was first concentrated on the biological studies needed for interpretation of the behaviour and effects of the scale infestations. However, plans were made for a distribution study in the spring of 1938 when the conspicuous female egg sacs make it possible to detect the prevalence of scale infestations on the trees by visual methods.

In October 1937, the Office of Forest Pathology reported a series of new areas in which evidence of flagging had been found during the course of the recent scouting program. At Mr. Carter's request a brief survey was made, largely in cooperation with Dr. Gill's office, during the period from November 14 to 24.

A report was submitted by McKenzie under the date of December 1, 1937. This recorded the presence of the scale in all of the 10 ponderosa pine areas examined.

Although this preliminary survey indicates quite strongly that the scale is connected with typical flagging injury, it is felt that the present amount of data is inadequate for final conclusions or decisions on this point alone. The correlation should be based on sound statistical data such as can be secured by a series of population counts both in flagged and flag-free areas.

TABLE I

Experimental Trees Artificially Infested With Matsucoccus scale.

Locality	Tree number	No. twigs infested 4/30-5/1 1936	Date examined	No. twigs flagged	Total to date
Lynx Creek	A	30	May 24, 1937 Oct.13, 1937:	None	None
Lynx Creek	B	15	May 24, 1937: Oct.13, 1937:	15 0	15
Lynx Creek	C	20	May 24, 1937: Oct.13, 1937:	None	None
Cold Springs	D	20	May 24, 1937: Oct.13, 1937:	1 6	7
Cold Springs	E	20	May 24, 1937: Oct.13, 1937:	13 0	13
Cold Springs	F	20	May 24, 1937: Oct.13, 1937:	11 5	16
Cold Springs	G*	20	May 24, 1937: Oct.13, 1937:	0 3	3
Cold Springs	H	20	May 24, 1937: Oct.13, 1937:	11 0	11
Cold Springs	I	35	May 24, 1937: Oct.13, 1937:	20 0	20
Cold Springs	J	20	May 24, 1937: Oct.13, 1937:	11 4	15

*Dr. West states that "The artificial infestation on this tree was not very successful since difficulty was encountered in locating many scale in the survey made in December 1936".

V. FURTHER WORK NEEDED TO ROUND OUT PRESENT PROJECT.

The following phases of the entomological study are now projected and under the present set-up of funds will be continued to July 1, 1938.

1. Biological work, including the histological studies showing effects of larval feeding upon the plant tissues. A progress report upon these studies will be ready about March 1st, 1938.
2. A field survey of sufficient intensity to show correlation between distribution of the scale and flag injury, to be completed in May and June, 1938.
3. Results of the artificial infestation experiments on trees selected and treated during the 1936 and 1937 seasons. These experiments should be extended far enough to determine whether flagging may occur two or more years after scale populations become established on the internode.
4. Experiments to develop a method which will successfully control the scale on individual trees. The objective of this experiment will be the possible application of control on park and shade trees, and for use in the type of experimental work suggested under 5, below.
5. A further experiment to determine whether flagging injury can be checked by control of the scale on trees now infested. It will be of little practicable value since control of the scale as the causative organism can hardly be considered an economic undertaking in forest areas. The experiment is proposed primarily to secure further evidence on the scale as a cause of the flagging. If a conclusion can be reached on the basis of other evidence this experiment had best be abandoned.

VI. DISCUSSION.

This report is intended to present for preliminary use such information as is now available, bearing on the connection of the scale, Matsucoccus sp., with the flagging of ponderosa twigs, an injury that is also termed "twig blight".

The evidence, if considered from an entomological standpoint only, seems to point quite conclusively to the assumption that the scale is either the direct cause of or is indirectly connected with this injury. It is apparent that, if the feeding habits of the insect alone do not cause flagging, some other organism which produces the same effect is associated with the injury caused by the insect. It seems quite inadvisable to come to any conclusions on this point until the pathological considerations have been cleared.

Material consisting of the flags which had developed on the artificially infested trees was turned over to the Forest Pathology Laboratory at Prescott, and it is expected that a report will be prepared giving results of the cultures or other findings which will throw light upon this angle of the problem. For the present we have only the one sided picture, the high lights of which are the following:

1. Matsucoccus sp. scale has been found in all ponderosa pine areas where there is flagging typical of the twig blight.
2. Flagging injury has been found only in areas where Matsucoccus scale occurs in relative abundance.
3. Introduction of Matsucoccus scale on trees in a flag-free and scale-free area resulted in a relatively high percent of flagging of the infested twigs soon after the completion of larval feeding and development. No flags developed on non-infested twigs on these experimental trees or in this local area.
4. Where the larvae had settled and fed upon the twigs, necrotic plant cells were formed in the immediate vicinity of the stylet punctures. This was much more noticeable where several larvae were grouped than where only a single larva was feeding. These necrotic areas became much more pronounced as the season advanced.
5. That this type of injury (formation of necrotic plant cells) may ultimately develop into flagging is yet to be proven. The full effect of the injury should become apparent just prior to emergence of preadults in the spring, and this period has not as yet been covered by the histological studies now underway.

Berkeley, California.
December 20, 1937.